

# Cyclone Seroja at Yarragadee Geodetic Observatory

## Preparation and Effect

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### Introduction

On the 11<sup>th</sup> April 2021, Cyclone Seroja crossed the Western Australian coast and, just below category 3 storm level, passed almost directly over the Geodetic Observatory at Yarragadee. Several hundred homes along the cyclone's path were destroyed or severely damaged. The worst of the damage occurred in the towns of Kalbarri where the cyclone made landfall, and Northampton. Luckily, although a lot of ancillary infrastructure at the Observatory was damaged, very little impact to geodetic operations occurred.

### Preparation

Thankfully, the Midwest community had three days warning of the predicted possible cyclone paths and preparations could be made.



Figure 1: Bureau of Meteorology threat map for Cyclone Seroja issued 48 hours prior to expected impact

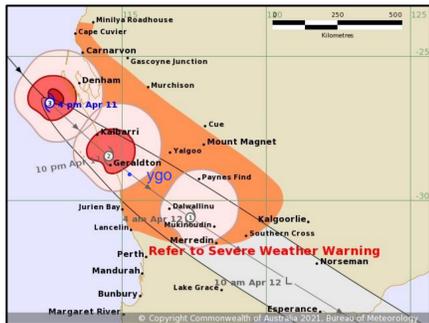


Figure 2: Bureau of Meteorology threat map for Cyclone Seroja issued 6 hours prior to expected impact

At Yarragadee, we checked and tightened all tie down cables and replaced any defective or missing ones. Fortunately, we had concrete anchor points installed because of previous cyclones in the late 70's. The two NASA vans were well tethered in all directions except for the MOMS van to the east. As for the VLBI dish, it was decided we did not have time (an EWP would be needed) to tie the 12m main reflector to its anchor footings. Since the dish was designed to withstand 100 mph winds in stow, untethered, and the cyclone was expected to weaken rapidly once it crossed the coast, we felt ok with that.



Figure 3: New tie down cables installed on NASA MOMS van

The site was tidied and, with the sky darkening in the west and the wind steadily increasing, by 1300 local all staff evacuated the site to protect their homes.

### Impact

Around 2100 local the cyclone crossed the coast and power and most communications went down at all staff homes. At that time winds at Yarragadee were a steady 70kmh. The Observatory continued to be monitored by the VLBI operations team at the University of Tasmania. The two anemometers on-site recorded a maximum wind gust of 162kmh sometime between 2125 and 2147. At that time the operations building lighting circuit was tripped, most likely when the verandahs and carport departed. The eye of the cyclone passed over YGO from 2200-2215 after which, the winds increased dramatically again – back to around 160kmh. Fortunately the cyclone was travelling abnormally quickly and wind gusts over 140kmh were only felt for about 25 minute in total, which significantly reduced the risk of really extensive damage.

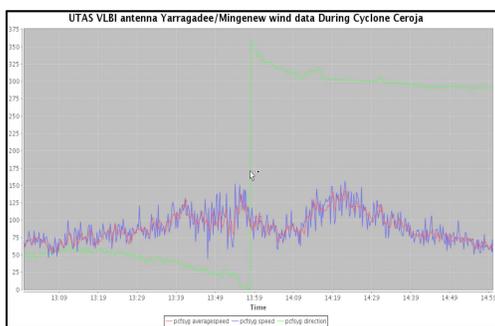


Figure 4: YGO VLBI antenna Yarragadee/Mingenew wind data During Cyclone Seroja Courtesy Brett Reid UTAS

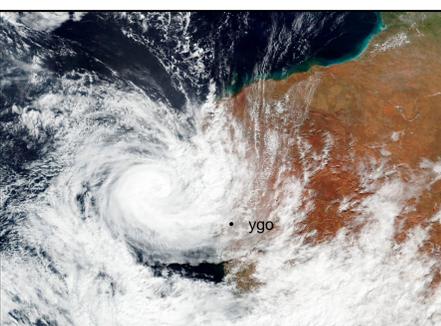


Figure 5: Cyclone Seroja approaching the Western Australian coast – image courtesy NASA

### The Damage

Access to YGO next morning was slow going, with many large trees having fallen across the road, especially as we got closer to the Observatory. The appearance of a lot of roofing sheets in the bushes and snapped power poles on approach, didn't bode well.

Infrastructure impacted:

- Mains power out for 11 days (backup generator ok)
- 3 bay carport destroyed
- Operations building verandahs gone – causing water to enter maser room
- Two sheds lost some roofing
- Gravity hut and VLBI shed had damaged timber framed walls
- Communications tower bent
- MOMS stairs, weighing about 400kg blown across compound
- Perimeter fencing damaged
- MOMS van appeared to have moved slightly to the west



Figure 6: The carport was severely damaged



Figure 7: A lot of nearby property was destroyed including these iconic landmarks



Figure 8: Hundreds of the trees nearby and much of our security fencing were damaged



Figure 9: The MOMS van access stairs were moved but basically undamaged. Note the SSC/USN 13m dish forced down through hard limits in the background. Inset: The communications tower was slightly bent when the departing verandah struck it, but the two anemometers at the top functioned throughout

### Effect on Geodetic Infrastructure

SLR tracking resumed within 36 hours of Cyclone Seroja passing through. There was a small (<0.008 degree) offset in az/el biases post cyclone, but this was removed with a quick pointing adjustment using mirror B. The MOMS van had moved about 10mm west relative to the 75cm telescope mount, judging by the mount wrap arm and the floor slot it used to go through. The floor plate slot needed enlarging for the arm to function. VLBI operations resumed once a new pointing model had been determined and adopted (elevation had changed by 0.2 degrees) and solid communications had been restored – two 24hr experiments were missed.

The Geoscience Australia survey team performed a "mini" (VLBI not included) local tie survey two months post cyclone. Preliminary results confirmed that negligible movement of either the IVP or ground targets had occurred.

Year	de	dn	du
2021	-22.1411	6.7049	3.2234
2010	-22.1418	6.7038	3.2265
Diff	0.0007	0.0011	-0.0031

Figure 8: The GA survey team found very little change after the cyclone between the SLR IVP and GNSS YAR2 antenna – the full survey report is expected soon

### Conclusions – lessons learned

- YGO came through direct impact of a category 2 severe tropical cyclone relatively unscathed, but with most climate models showing the Midwest region of WA will experience an increasing number of cyclones in future, we need to be even better prepared.
- The van tethers seemed to work well but the MOMS van should ideally be anchored to the east as well – however this would involve digging a footing close to Don92
- Having the site unmanned during severe cyclone events was a good decision.
- All ancillary structures should be cyclone rated or well tethered too. We were very lucky none of the debris seriously damaged critical infrastructure: metal from the carport or verandah struck the rear panels of the 12m, fortunately side on to it.
- Repairs have almost been completed!



Figure 9: 18 months after Cyclone Seroja caused extensive damage to the infrastructure at YGO, repairs are almost complete. Note the new much improved communications tower with anemometers in place ready for the next big event. The new carport is cyclone rated.

